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Social Image in Public Goods Provision with Real Effort

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We study public goods game where the contribution efforts are observable. When the players are observed, they contribute more and free-riding diminishes significantly. On the other hand, presence of an audience does not affect the performance of players if there is no strategic aspect of the game, i.e. when they play private goods game. The findings are in line with the predictions of the social image theory where a player's contribution is also a signal to an audience regarding how much she cares about contributing to the public goods.

Keywords: Public goods; effort; experiment; social image.

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1. Introduction

Voluntary contributions to the public goods, such as recycling, not littering, or painting the walls of a community center require real effort, and they are mostly observable. Being observed by others may affect the decision of the contributors who have social image concerns. This paper studies the effect of an audience while working for the provision of the public goods.

In a typical public goods experiment, the subjects are asked to divide an endowment between public and private accounts. The parameters are selected so that the marginal return of the contribution to the public account is lower than the marginal cost of it and therefore, there are monetary incentives to free ride. However, contribution is socially optimal and therefore examining the motives that encourage higher contributions is important for the social welfare. It has been shown both in the field and the laboratory that individuals act more pro-socially when they are concerned about social approval (see e.g. Hollander, 1990; Andreoni and Petrie, 2004; Rege, 2004; Rege and Telle, 2004; Soetevent, 2005; Dana, Cain, and Dawes, 2006). Charities seem to address this concern of contributors by making contributions identifiable.

In public goods where the provision requires real effort, not only the final amount of contribution but also the process of contribution is observable. One may argue that contributors who seek for social approval will be highly motivated by the presence of an audience in such settings. In order to measure the effect of social image at the time of decision making rather than after the decision making, we provide a novel experimental design of public goods where the provision requires real effort. In other related studies, which are testing the effect of identifiability on voluntary contributions, the subjects know that their contribution amounts will be announced at the end (e.g. Andreoni and Petrie, (2004); Ariely, Bracha, and Meier, (2009)). In comparison to those studies, we find much higher contributions in the presence of audience when the process of decision making is observable.

In our experiment, the subjects first played a public goods game where they need to solve costly tasks in order to contribute to the public goods.[1] In our observer treatment, subjects are watched by a third-party[2] who is not involved with the public goods generated. In no-observer treatment, they performed in private. After completing the public goods game, subjects are asked to solve the costly tasks for their private benefits. In this part subjects are either observed or not depending on the treatment they are in.

One may argue that being observed may affect the performance. For example, a contributor may make more mistakes because of the stress the audience causes. This effect is independent of the strategic component of playing the public goods game. We control for this effect in our private goods part of the experiment where each subject is asked to perform the costly task only for her private benefit.

The results show that presence of an audience increases the contribution to the public goods significantly without affecting the productivity. We confirm that the contributors work harder to impress the audience about how much they care for the society.

It has been argued in the literature that individuals may contribute to the public goods in order to signal how wealthy, generous, altruistic or kind they are (Glazer and Konrad, 1996; Harbaugh, 1998a,b). The social image concern of a player in a game has been modeled as a

[1] There are some other public goods experiments that have a real effort component differently. For example, in Kroll, Cherry and Shogren (2005), subjects, after earning their endowments, decided how much of their endowment to contribute to a public account; in Stoop, Noussair, and van Soest (2009), not contributing to the public goods requires effort.

[2] This allows us to isolate the effect of social image on contributions from other strategic effects one may think of when the observers are the other players of the public goods game. For example, when the players observe each other, one may base her strategy on other players' actions or she may try to affect others' beliefs about her action and therefore change their contribution rates.

signaling game between an audience and the player (Bernheim, 1994; Glazer and Konrad, 1996; Bernheim and Serverinov, 2003; Benabou and Tirole, 2006; Andreoni and Bernheim, 2009).

Benabou and Tirole (2006) study the interaction between intrinsic and extrinsic motives and reputational concerns in determining pro-social behavior. Ariely, Bracha and Meier (2009) test this model in a public good experiment, and they study the crowding out hypothesis. Here we are interested in solely the social image concerns in pro-social behavior, and therefore we fix the return rate on public goods. Hence, we use a model based on the model of Andreoni and Bernheim (2009) which applies naturally to our design.

Andreoni and Bernheim (2007, 2009) (for the rest of the paper, these papers are referred as AB) introduce a model of social image in order to explain the robust generosity of players in dictator games. They model the dictator game as a signaling game between an audience and a dictator where the dictator is assumed to have a privately known type which is her taste for being fair. The dictator also values what the audience thinks her type is. We revisit their theory in our setup and show that it is capable of explaining our data. However, we need to modify their theory for the public goods setup. In the dictator game setup they take the fair outcome (50-50 division of the money between the dictator and the receiver) as the reference point. The dictator gets disutility from deviating from the fair outcome. In the public goods game, the reference point is the socially optimal contribution level and the contributor who cares a lot about working for the society suffers if she is not working at the full capacity. Indeed, our data confirms that a subject's performance in the private goods game serves as a reference point for the social image theory.

The theory predicts that individuals who care about how much they contribute to the public goods will make contributions depending on their types. A mass of low types will pool by contributing zero and the other types will contribute positive amounts. If the contributors are observed while they are contributing to the public goods, the contribution levels will increase. No type except the lowest type will contribute zero. These findings are supported by our data.

In section 2, we describe our experimental design and present our results. Section 3 presents social image theory. Section 4 is a conclusion.

2. Experiment

We have a novel public goods game design where in order to produce the public goods, the contributors need not only to pay the monetary cost of contribution but also to exert some effort. This design captures how public goods are produced in many real life situations, such as keeping the streets clean, recycling, or painting the walls of a community center. In most of these types of voluntary contributions, it is hard to work for the society by keeping one's effort secret. It is reasonable to expect that observability will affect how hard individuals work for the society. In our design, we check how efforts for public goods production are affected by the presence of some third party audience.

2.1. Method

The experiment was run at the Experimental Economics Laboratory at the University of Maryland (EEL-UMD). All the subjects were the undergraduate students of the UMD. 124 undergraduate students who were recruited via our online recruitment system participated. Each session took less than 30 minutes. The experiment involved six sessions and no subject participated in more than one session. In each session one of the two treatments were administered. 80 subjects participated in Treatment 1 and 44 subjects participated in Treatment 2. The experiment was programmed in z-Tree (Fishbacher, 2007).

In Treatment 1, subjects are separated at random into equal groups of contributors (actual players of the public goods game) and observers in a session. In Treatment 2, all the subjects were contributors. The contributing subjects were seated in isolated computers. In a given session if there were observing subjects, each of them was randomly matched with a contributing subject and the observer just stood behind the contributor and watched her computer screen while the contributor was playing the game. In all sessions, the computer randomly assigned each contributing subject to a group of four individuals. A subject did not know the identity of the other group members in her group. The rules of the game for the contributors were identical in both treatments.

Each session had two parts: public goods game and private goods game.[3] In the public goods game, subjects were initially endowed with $5.00. They were asked whether they want to complete a task for their group. If they said *yes* then they paid $0.50 to see a task. The tasks were defined as adding up five two-digit integers that were randomly generated by the computer and presented on the contributing subjects' screens. This task was used by Niederle and Vesterlund (2007) in private goods settings. Each correctly completed task generates $1 in the public account. The amount that was accumulated in the public account of the group is equally shared by the group members. Therefore, $0.25 was earned by each group member for each correct answer of the group.[4] After completing a task, subjects were asked whether they wanted to see another task and the same procedure continued for five minutes. After completing each task, the computer reported whether the answer was correct or not. The answers cannot be changed after

[3] In the instructions, we did not call them public/private goods games, instead they are named as Part I and Part II.

[4] Subjects can attempt as any many tasks they would like to; despite that none of the subjects bankrupted.

the report. At the end of the public goods game, each subject learned how many tasks she completed correctly and how many tasks her group completed correctly.

In Treatment 1, each observer was standing behind an assigned contributor while she is completing tasks. The observers were asked to look at only the computer screen of the assigned contributor while she is playing the games. Each observer was provided a pen and a piece of paper and asked to report if the contributor completed each task correctly or not. The observers were paid according to how accurately they reported the performance of the contributors. The contributing subjects knew the payment schemes of the observers therefore they were aware that the observers had no benefit from the public goods game. This was important part of the design because we wanted to see the isolated effect of being observed on the provision of public goods. If the other contributors were the observers then this would interact with the contribution strategies and we aimed to avoid this.

After completing the public goods game, the private goods game started.[5] Again, $5.00 initial endowment to each subject was given. This time the contributing subjects were asked to play a similar game for another five minutes. They were asked to complete the tasks to earn money only for themselves. They were not group members anymore. They again decided whether to see a costly task or not and this time they earned money only from their own correctly completed tasks. In this part, seeing a task cost $0.50 and each correctly answered task earned $0.75, i.e. for each correct answer, the subjects earned $0.25. If it was a session with observers, then the observers kept watching the private good contributors in this part as well.

[5] In this paper, we compared the effect of observers in public and private goods games, separately. Therefore, in order to control for the order effect of the play, in both treatments the order was fixed such that the subjects played the public goods followed by the private goods games. Furthermore, since the behavior in public goods game is our utmost importance, the subjects played it first to avoid any spillover effects.

When contributing to the public goods requires exerting effort, one needs to have a measure for how generous contributions were comparing to how much potentially subjects could contribute. For example, a subject who contributed to the public good by solving three tasks can be considered generous if that is maximum she can do in five minutes given the cost of effort and the failure rate of the subjects. However, if she is shading some of her effort then she cannot be considered very generous. Therefore, we need a design that provides a good reference for that measure. We used the number of tasks solved in the private goods game as the maximum amount a subject could have contributed in the public goods game if she wanted to.

In the experiment, we did not identify how much a subject earned and we did our best to convince subjects that the experimenters do not monitor or observe the decisions of each subject. In order to do that in each session, we had two experimenters: one in the laboratory and one in a different room. The one in the laboratory did not know what subjects are doing since she cannot see their screens. The subjects are assigned random ID numbers and the server collects data under the ID numbers. The experimenter, who stays in a different room, sees the data collected in the server and prepares the payment envelopes. She seals the envelopes and writes the ID numbers on them. At the end of each session, the proctor goes and takes the envelopes from the other room and distributes them to the subjects. We explained this procedure to the subjects before the experiment starts.

2.2. Results

The summary statistics of our data from public goods games of the experiment is presented in Table 1. The first column summarizes the data for the without-observer treatment, and the second column presents the corresponding statistics for the with-observer treatment. Since our game requires subjects to exert effort in order to contribute to the public goods and since not all effort necessarily leads to a successful contribution (subjects may solve the task incorrectly) we compare the number of attempts and the number of successful attempts (correct answers) separately.

TABLE 1

PUBLIC GOODS PROVISION

	Averages	
	Without-observer	With-observer
Attempts	4.25 (0.497)	7.95 (0.496)
Attempts conditional on not free riding	5.34 (0.471)	8.15 (0.464)
Correct answers	3.86 (0.46)	7.15 (0.48)
Correct answer rates (correct/attempt) when # of attempts>0	0.92 (0.02)	0.90 (0.02)

Average with standard errors in parentheses.

Being observed affects the contributions to the public goods. First of all, with observer 1 out of 40 subjects contributed zero, however without observer free riding rate increased to 20.45% (9 out of 44 subjects). Fisher's exact test yields that free-riding decision is significantly affected by being observed ($p=0.011$). Using non-parametric Mann-Whitney tests, we find that attempts, attempts conditional on having positive attempts, and correct answers (contributions to the public goods) in two public goods games are significantly different at the $p<0.001$ level (see Table 2). However, there is no significant difference between correct answer rates (#correct answer/ #attempt) for non-zero attempts of public goods games with and without observers ($z=1.549$, $p=0.1213$).

TABLE 2

MANN-WHITNEY STATISTICS FOR PUBLIC GOODS PROVISION

	Without- vs. with-observer
Attempts	-4.447 (0.0000)
Attempts conditional on not free riding	-3.661 (0.0003)
Correct answers	-4.245 (0.0000)
Correct answer rates (correct/attempt) when # of attempts>0	1.549 (0.1213)

Mann-Whitney z-statistics with p-values in parentheses.

Figure 1 demonstrates the distribution of contributions in public goods games with and without observers. Note that when there are observers the distribution shifts right.

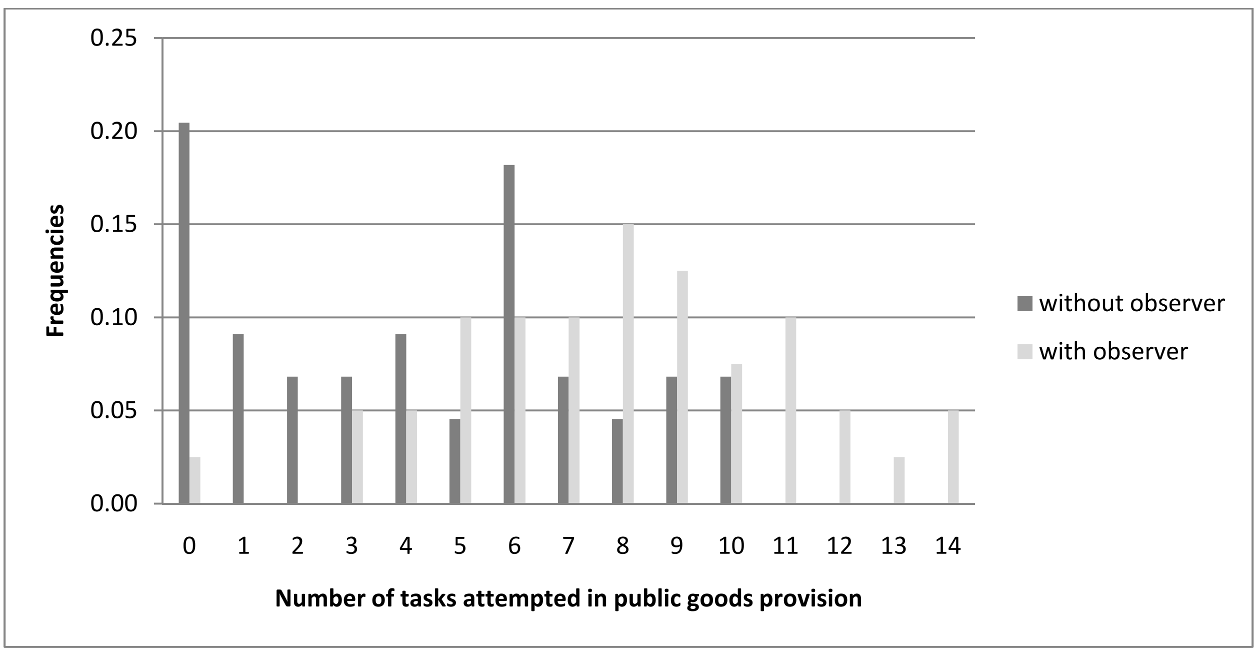

Figure 1: Distribution of number of tasks attempted in public goods provision with and without observer.

Moreover, there is a first order stochastic dominance between these two distributions (see Figure 2).

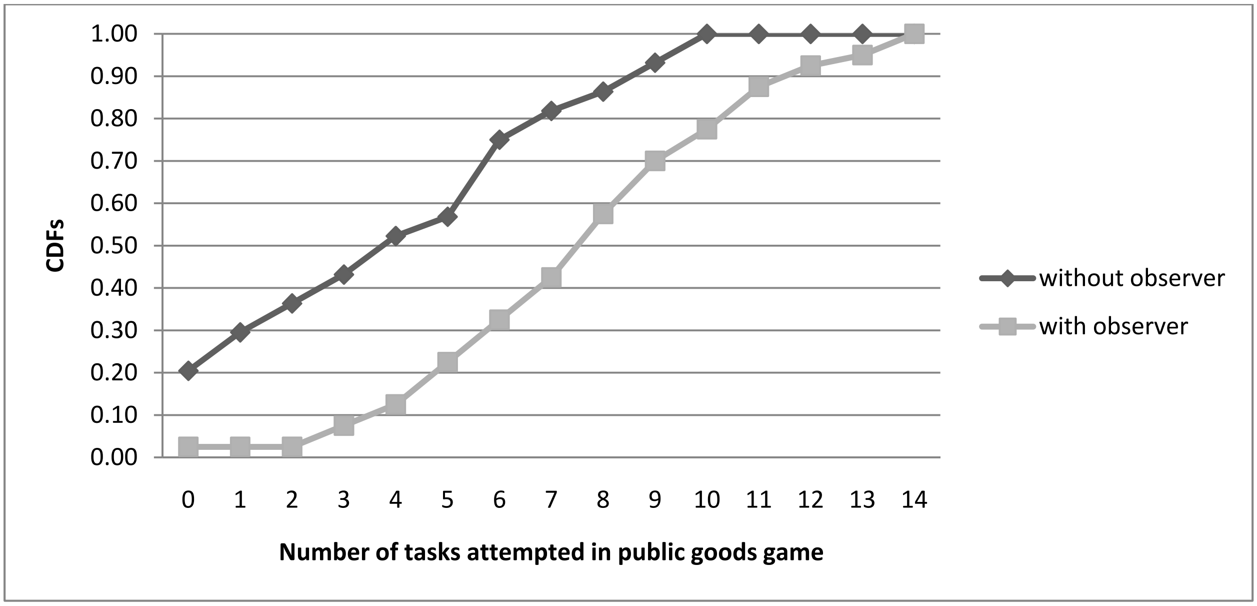

Figure 2: Cumulative distribution functions of number of tasks attempted in public goods provision with and without observer.

Table 3 summarizes the average attempts, correct answers and correct answer rates in private goods games. In private goods games, there is no subject with zero attempts.

TABLE 3

PRIVATE GOODS

	Averages	
	Without-observer	With-observer
Attempts	11.05 (0.52)	10.85 (0.44)
Correct answers	9.52 (0.48)	9.65 (0.47)
Correct answer rates (correct/attempt)	0.86 (0.02)	0.88 (0.02)

Average with standard errors in parentheses.

Using non-parametric Mann-Whitney tests, we find that the presence of observers does not affect the performance and productivity of subjects (see Table 4, and Figure 3 and 4).

TABLE 4

MANN-WHITNEY STATISTICS FOR PRIVATE GOODS

	Without- vs. with-observer
Attempts	-0.162 (0.8710)
Correct answers	-0.343 (0.7318)
Correct answer rates (correct/attempt)	-0.628 (0.5299)

Mann-Whitney z-statistics with p-values in parentheses.

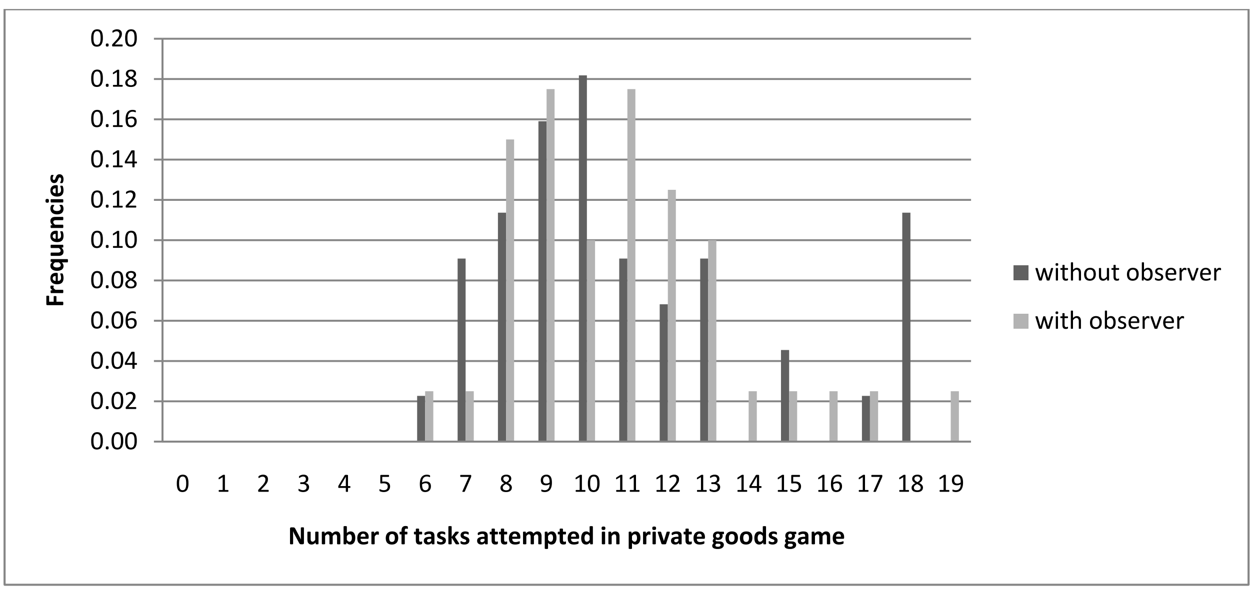

Figure 3: Distributions of number of tasks attempted in private goods with and without observer.

Figure 4: Cumulative distribution functions of number of tasks attempted in private goods with and without observer.

Contribution rate in a public goods game is the ratio of actual contribution to the public goods and the maximum contribution one can make if she wanted to. In the literature, public goods games typically do not require costly effort in order to provide public goods and the initial endowment is taken as the maximum contribution level. The literature finds contribution rates between 0.4 and 0.6. In our setup, the number of attempts in private goods games is used as the maximum potential contribution level. We find that the average contribution rate without observer is 0.38 which is slightly less than the lower bound found in the literature. However, in the presence of observers, this rate jumps to 0.71. Mann-Whitney test shows that the contribution rates with and without observers are significantly different (z=-5.255, p=0.0000). In Ariely, Bracha and Meier (2009) the contribution rates increase from 0.57 to 0.63 when the subjects know that they will announce their contributions at the end of the experiment.[6] Andreoni and Petrie (2004) also find an increase in contributions when the subjects know their group mates

[6] This result is found for their "good couse" treatment. For the "bad cause" treatment the increase is from 0.3 to 0.44 when the contributions are identifiable.

and learn each others' contributions ex-post. Although this study is for repeated public goods games, when we look at their first round data, the contributions increase approximately from 0.30 to 0.54.[7] The direction of the effect of observability in these two studies is the same as our findings. However, our results indicate that when the observations are made during the contribution process rather than ex-post, much higher jumps and much higher rates are found.

Figure 5 shows the contribution rates of each subject. It can be clearly seen from Figure 5 that: (i) the lack of observers lead to positive mass of zero contribution rates, (ii) contribution rates are higher in the presence of an observer, (iii) the highest contribution rate without observer is less than 1, but it is equal to 1 with observer. We will revisit these points in the theory section.

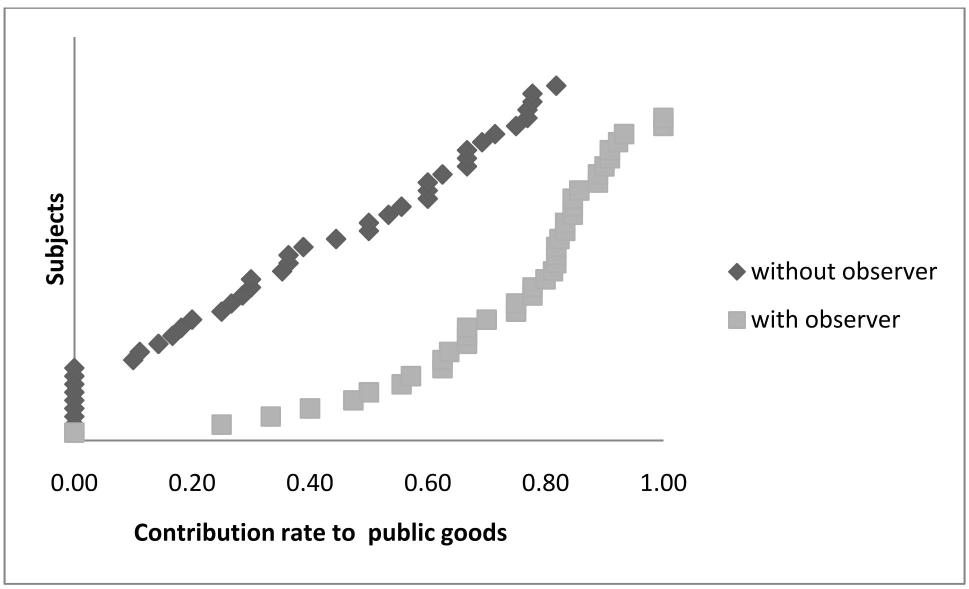

Figure 5: Contribution rate to public goods of each subject with and without observer.

The optimal behavior of a selfish individual in a public goods game is not to contribute at all with and without observer. However, in our experiment there is positive contribution to the

[7] Since the experiment of Andreoni and Petrie (2004) is a repeted game, besides the audiance effect, the subjects may want to contribute high amounts to the public account in the first round just to encourage their groupmates to contribute later.

public goods, and it increases in the presence of an audience. One may argue that this difference may be also affected by other motives in addition to or besides the social image. For example, in the presence of an audience the performer may feel stressed and make more mistakes, or she may want to impress the audience and attempt more tasks or attempt fewer tasks in order to minimize her mistakes. Our private goods game has the right nature to test these effects, and there are no significant differences in the number of tasks attempted or correctly solved. Hence, we can rule out these other affects of the audience in our setting.

The theories of inequity aversion, altruism, and warm glow are capable of explaining positive contributions to the public goods. However, these theories are silent on the effect of audience. Next, in Section 3, we show that the social image theory is capable of explaining our experimental results. In a nutshell, the social image theory predicts that contribution to the public goods increases when the contributors are observed. However, there is not any effect of observers when it is a private goods game.

3. Social Image Theory

N>2 individuals play a public goods game in the presence of third-party observers. Each individual has an initial endowment, E, which can be either used for individual consumption or spent to contribute to the public goods. Contribution is costly with unit cost $c>0$. The contribution of individual i is denoted by $x_i \in [0, \overline{x}_i]$ where $\overline{x}_i$ is the capacity of the individual and it is the highest amount she can possibly contribute. Contributions are made simultaneously and the total contribution returns back to each individual with return rate $r>0$ where $c>r$.

Assume r is a decreasing function of N. Let $x=(x_1,...,x_N)$ be the vector of contribution levels of each individual. The monetary payoff of individual i from contribution vector x is

$$E-cx_i+r\sum_{j=1}^{N}x_j$$

Next, we modify the social image model of AB for public goods game. We keep the notation as close as possible to AB. Individual i not only cares about how much monetary payoff she gets but also cares about how much she contributes to the public goods comparing to her capacity. She gets a disutility from the discrepancy between her actual contribution level and her capacity depending on how much she cares about the society. We will consider her capacity as the reference level, R. The utility of an individual increases, when her contribution gets closer to the reference level. Each individual has a type for how much she cares about contributing to the public goods. Type of individual i is t_i. The type of an individual is a private information and it has cumulative distribution H on the interval $[0,\bar{t}\,]$. The distribution of t is atomless and has full support on $[0,\bar{t}\,]$.

When an individual is observed while contributing to the public goods, she exhibits social image concerns, in other words she enjoys being considered as a high type by some audience. Let m denotes the social image of an individual whose contribution to the public goods is observed. She cares about her monetary payoff ($E-cx_i+r\sum_{j=1}^{N}x_j$), her social image ($m$), and the difference between her contribution (x_i) and her reference point (R):

$$u_i(x,m,t_i)=F(E-cx_i+r\sum_{j=1}^{N}x_j,m)+t_iG(x_i-R)$$

F is unbounded, twice continuously differentiable, strictly increasing, and F_1 is bounded in the domain for all *m*, strictly concave in the first argument. $G:\mathbb{R}\to\mathbb{R}_+$ is twice continuously differentiable, strictly concave and reaches a maximum at zero.[8]

Social image depends on the observers' perception of how much a contributor cares about contributing to the public goods. If the observers know that the type of the contributor is $\tilde{t}$ then the social image is $\tilde{t}$. If the observers' belief about the type of the contributor is distribution $\tilde{H}$ then $B(\tilde{H})$ is the corresponding social image. We impose the same assumptions as AB on the social image, *B* (see AB, 2009 for the details of those assumptions).

Since the contributors are observed, the observers' perception about the contributors' types depends on the contribution level. The contributors know about this as well. A pure strategy equilibrium of this signaling game is pairs of mappings $(x_i^*, P_i)_{i=1,\dots,N}$ where contribution strategy x_i^* maps types to contribution levels and P_i maps contribution levels to inferences. Contribution strategies are optimal and the inferences are consistent with the contribution strategies in equilibrium. We focus on pure strategy equilibria which satisfy the D1 criteria (see Cho and Kreps, 1987). Consider the types from some interval $t\in[t',t'']\subseteq[0,\bar{t}]$. In a separating equilibrium, for each type $t\in[t',t'']\subseteq[0,\bar{t}]$ the contribution of type t should satisfy the following first order condition which is derived from taking derivative of

$$F(E+(-c+r)x_i(m)+r\sum_{j\neq i}x_j, m)+tG(x_i(m)-R)$$

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[8] This payoff function is similar to the social image model introduced in AB (2007, 2009) for dictator games. In AB (2007, 2009) the utility function of a dictator who has \$1, sends \$x to a receiver and has type t is *F(1-x,m)+tG(x-1/2)* where ½ is the reference point for the dictator game. The dictator's monetary payoff decreases with how much she sends to the receiver; in the public goods game, the contributor's monetary payoff decreases with how much money she puts into the public account. Therefore, the properties of *F*, and *G* functions in AB (2007, 2009) and here are the same.

with respect to *m* and setting it equal to zero at *m=t*:

$$x_i^{'}(t) = -\frac{F_2\left(E + (-c+r)x_i(t) + r\sum_{j\neq i} x_j, t\right)}{(-c+r)F_1\left(E + (-c+r)x_i(t) + r\sum_{j\neq i} x_j, t\right) + tG'\left(x_i(t) - R\right)} \tag{1}$$

For the initial condition (0,0) let x_i^0 be the solution to Equation (1). Define $\tilde{t}$ as the type that solves $x_i^0(t) = R$.[9]

The next result characterizes the equilibrium that satisfies the D1 criteria. It shows that the equilibrium has a unique contribution strategy which is weakly increasing in type. The types that are greater than a certain threshold contributes at their upper bound, $\overline{x}_i$. All the types that are below this threshold level separate by contributing according to the solution to the first order condition, Equation (1).

The only difference between dictator and public goods games that may affect the incentives is that in the latter one some portion of the money that is sent returns back to the individual. Nevertheless, the proofs of AB can be easily modified for our public goods game setup. Hence we will omit the proofs and refer to the corresponding statement from the papers of AB when needed.

Theorem 1: [Theorem 3 and 4 in AB (2007)] *There exists a unique equilibrium contribution function* x_i *which can be characterized as follows:*

[9] This expression has a unique solution for any initial condition (t', y) (contribution y for type t') such that $y \geq x_i^N(t)$ where $x_i^N(t)$ is the optimal contribution level when contributors are not observed and the social image does not play a role; for any such initial condition, the solution to the differential equation above is strictly increasing in type.

1) *The separating equilibrium exists if and only if* $\overline{t} \le \tilde{t}$ *. Moreover,* $x_i^*(t_i) = x_i^0(t_i)$ *for any* $t_i \in [0, \overline{t}\,]$.

2) *The equilibrium contribution strategy is pooling at least for some types if and only if* $\overline{t} > \tilde{t}$ *. For the zero type,*

   (i) if contributing zero when the observers understand that the type is zero is worse than contributing the reference level while the observers' inference is B(H) then all the types contribute at the reference level, R, in the equilibrium i.e. $x_i^*(t_i) = R$.

   (ii) otherwise, there is a threshold $t_0 \le \tilde{t}$ *such that for any* $t_i \in [0, t_0]$ $x_i^*(t_i) = x_i^0(t_i)$ *and for any* $t_i \in (t_0, \overline{t}\,]$ $x_i^*(t_i) = R$.

According to Theorem 1, the equilibrium is separating, pooling or a combination of two. If the support of types is not wide, then the equilibrium is separating. In all these cases, no type except type-0 contributes zero to the public goods.

Public goods provision without social image:

When the individuals are not observed while contributing to the public goods, they cannot be concerned about their social images. This setup is similar to the case of AB (2007) where the types are commonly known, and social image is not inferred from the behavior. This can be modeled by $F_2=0$, or equivalently F dependents only on monetary payoff.[10] The first order condition that a separating equilibrium contribution function needs to satisfy is

$$F'\left(E - cx_i(t_i) + r\sum_{j=1}^{N} x_j\right)(-c+r) + t_i G'(x_i(t_i) - R) = 0 \qquad (2)$$

[10] We abuse the notation and denote F as a single variable function when there is no observer.

Theorem 2: [Theorem 1 in AB (2007)] *There exists a unique equilibrium contribution function* x_i^* *for every i such that:*

(i) For all t_i, $x_i^*(t_i) \in [0, R)$. *(ii)* $x_i^*(t_i)$ *is weakly increasing in* t_i *(strictly when* $x_i^*(t_i) > 0$ *and in that case* $x_i^*(t_i)$ *solves Equation (2)). (iii) There exists* $t_i^* > 0$ *such that* $x_i^*(t_i) = 0$ *for all* $t_i \le t_i^*$. *(iv)* $\lim_{t_i \to \infty} x_i^*(t_i) = R$.

The equilibrium characterized in Theorem 2 suggests that contributors whose types are smaller than a certain threshold do not contribute to the public goods. The ones with types higher than the threshold contribute positive amounts to the public goods and the higher the type is, the higher the contribution level is. No type contributes the reference level but the contribution approaches to the reference level while the type goes to infinity. These properties are demonstrated in Figure 6.

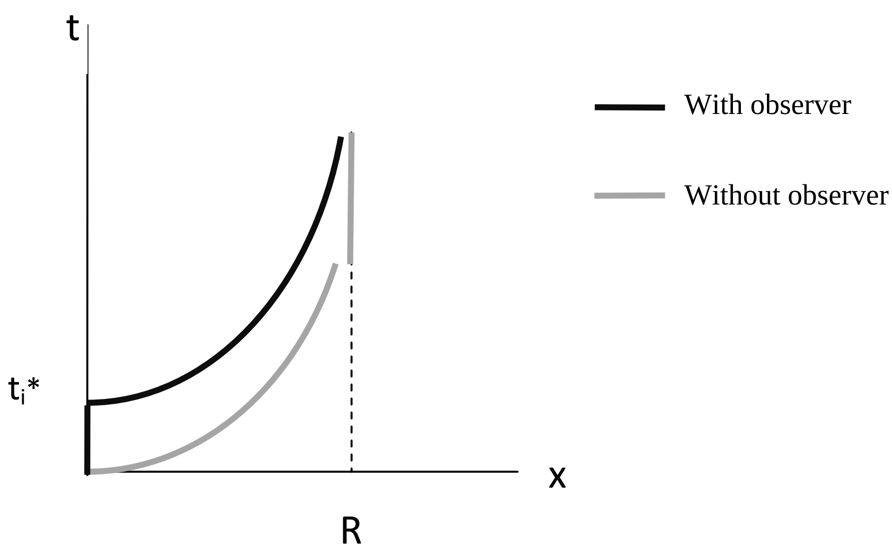

Figure 6: Equilibrium contributions with and without observer.

Our experimental results demonstrated in Figure 5 are well explained by the social image theory in Figure 6. In line with the theory, the contribution rates of 20.45% of the subjects were zero when there were no observers ($p<0.005$). However, only 1 out of 40 subjects had zero contribution rates in the presence of an audience. The contribution rates with observer were higher than that of without observer. Additionally, with observers some subjects contributed at their full capacity however without observer, no subject contributed more than 82% of their capacity.

Next, we provide some comparative statics for the equilibria characterized in Theorems 1 and 2.

Proposition 1: *(i) When social image is not involved, let* t_i^* *be the threshold type that is defined in Theorem 1.* t_i^* *decreases with the return parameter, r, and reference level, R, and increases with the cost of contribution, c. Moreover, the separating part of the equilibrium* $x_i^*(t_i)$ *increases for every type* t_i *if r or R increase, or c decreases.*

(ii) When social image is involved, $x_i^*(t_i)$ *increases for every type* t_i *if r or R increases, or c decreases whenever the separating equilibrium exists.*

In a typical public goods experiment, the marginal return from the public goods increases when the group size decreases, e.g. the total contribution is equally split among the group members. Hence, as the group size decreases, the marginal return increases and more contribution to the public goods is expected. Alternatively, it is argued in the literature that perhaps solely the actual number of participants may decrease the contribution level since it is crowded. Isaac and Walker (1988) experimentally demonstrated that the group size did not affect the contribution level unless it affects the marginal return (*r*). Indeed, the social image theory predicts that the actual number of participants will not affect the contribution level without accompanied by a change in marginal return.

Proposition 2: [Theorem 2 in AB (2007)] *For any type, the equilibrium contribution with observer is higher than that without observer.*

In our public goods experiment, the average number of tasks attempted or correctly solved when there are observers is significantly higher than that without observers (see Table 1 and 2). Moreover, the distribution of tasks attempted with observer first order stochastically dominates the distribution of contributions without observers (see Figure 2). All these are in line with Proposition 2.

Remark: The type of a contributor is her taste for contributing to the public goods. The social image is what the observers think about the contributor's type is. If there is no public good as in our private goods experiment, the players' behavior should be independent of their types and their social images because money is the only term in their objective function. When the return of effort is higher than the cost of effort in producing private goods, the individuals should work as hard as possible with or without observer.

Indeed, in our data for private goods, the subjects attempted in average to 10.85 tasks when there are observers and 11.05 tasks when there are no observers. These averages are not significantly different from each other (see Table 4). These results indicate that in our setting the presence of an observer do not create any social pressure that may affect the number of tasks attempted or their mistake rates.

4. Concluding Comments

The current study demonstrates that just being observed changes the incentives in a public goods game. The contributors do not free-ride when observed by strangers who are not a part of the public goods game and they contribute significantly higher amounts. There is no audience effect on the performance of the players when they play private goods game. Therefore, the change in behavior in public goods game is solely to give a message to the audience regarding something good about the contributors. The players who already have a preference for contributing would like to signal to the observers about their types on how much they care for the society. Besides using this finding as a tool to increase voluntary contributions to a charity, one may apply it to labor settings to diminish free-ridings in work place by making office space more open.

The observers in our design were randomly selected strangers. A natural question is how the audience effect changes depending on the identity of the observers and their relations with the contributors. Gender effects, cultural differences and having similar backgrounds are potential relevant social aspects that might be effective. Moreover, examining those in the field where social identities naturally occur would be interesting in order to understand the determinants of voluntary contributions.

The experiment tests the audience effect in a one shot public goods game when real effort is needed for contribution. It would be a fruitful exercise to check how the findings of this static game changes if the contributors interact repeatedly. It is a robust finding in the literature that voluntary contributions diminish over time. Effort involved public goods production and the presence of audience will probably alter these robust findings.

Finally, for many voluntary contributions, the contributors have an option to choose between working for the public goods and donating money. For example, if a community center needs to be renovated, one may either physically help the renovation or make donations to hire someone to do the renovation. It may be interesting to investigate the endogenizing the nature of contribution.

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Appendix

INSTRUCTIONS:

Welcome and thank you for coming today to participate in this experiment. Various research foundations have provided funds for this research. The instructions are simple, and if you follow them carefully and make good decisions, you can finish the experiment with a considerable amount of money, which will be paid to you in cash at the end. The exact method of calculating your final payment will be described.

We ask that you do not talk to any other participant in the room. If, at any time, you have a question, please raise your hand, and the experimenter will answer your question. Failure to comply with these instructions means that you will be asked to leave the experiment and all earnings will be forfeited. The experiment will last about 30 minutes.

In this experiment, a random ID number is generated for each computer. You will see this number on your screen. Your name will never be recorded in this study, and you will be known by these ID numbers. Another experimenter in another room will prepare the payment envelopes based on ID numbers without knowing your names. The sealed envelopes will be distributed to you by the experimenter in this room.

You are going to be randomly matched with another participant in this room. That participant is another volunteer, just like you, participating in this experiment. One of you (performer) will be performing several tasks that will be explained below. The other one (observer) will be standing next to the performer while he/she is performing. The observer is only expected to watch the performer and the performer's screen silently. **You are absolutely not allowed to talk to each other.**

If you are sitting in a workstation, then you are a performer. If you are standing, then you are an observer.

<u>Instructions for the performer:</u>

You will be randomly matched with three other performers in this room. Those will be your teammates, and your and their performance will affect your earnings. You will be asked to calculate the sum of five randomly chosen two-digit numbers that will appear on your screen.

There is a series of these tasks that you may solve. For your calculations, you may use the scratch paper and pen that we provided you. You cannot use calculators. Each team member has the same role.

When the experiment starts, you and your teammates will be given $5.00 each initially. Depending on your and your teammates' decisions, your final earnings can be more or less than $5.00.

At the beginning, a box saying "**Do you want to see the first task?**" will appear on your screen. Seeing a task costs you 50 Cents. If you want to see the task, you need to click on "**Yes**". By clicking on "Yes", you will spend 50 Cents and see five two-digit numbers on your screen. You are going to be asked to calculate the sum of these five numbers. When you finish, you need to enter your answer on your screen where it says "**Sum=**". When you are ready to submit your final answer, just click on "**Submit**". Once you submit your final answer, you cannot go back and change it anymore. The computer will tell you if your answer is correct or wrong. For each correct answer by a team member, your team will gain $1.00, and this amount will be equally shared by all the team members, in other words since there are four members, you will gain 25 Cents for each correct answer by your team. For the wrong answers, your team will not gain any amount.

If you do not want to see the first task, then you need to click on "**No**" when you see "**Do you want to see the first task?**" on your screen. Clicking on "No" does not cost or gain you anything. If you pick "No", then your role finishes.

If you solve the first task and submit your answer, then you will pass to the second task. Again a box will show up and say "**Do you want to see the second task?**" As before, you can click either on "**Yes**" or "**No**". Seeing a task costs you 50 Cents. If you pick "Yes", then you will see another set of five two-digit numbers that you are asked to add. Once you calculate the sum, enter it on your computer screen and click on "**Submit**". The computer will tell you if your answer is correct or wrong. Again, for each correct answer by a team member, your team will gain $1.00, and this amount will be equally shared by all the team members, in other words you will gain 25 Cents for each correct answer by your team. For the wrong answers, your team will not gain any amount. If you do not want to see the second task, then you need to click on "**No**" when you see "**Do you want to see the second task?**" on your screen. Clicking on "No" does not cost or gain you anything. If you pick "No", then your role finishes.

This same exercise will continue. You have 5 minutes to work.

Each team member starts with the first task. The ones who pick “Yes” continue seeing tasks. The ones who pick “No” stop seeing new tasks and their role finishes. When there is no team member left (in other words all team members picked “No”) or 5 minutes pass, we will calculate your earning.

Earning of the performer:

The computer will calculate the number of submitted correct answers by you and your teammates. For each correct answer by your team, your team will earn $1.00. You will gain ¼ of the total earnings of your team in addition to your initial $5.00. From this gain, the computer will subtract the cost of tasks that you have attempted to solve. Remember that seeing a task costs you 50 Cents. The difference will be your earning. This is calculated by the following formula:

$$\text{Earning} = \$5.00 + \frac{\text{Total correct answers of your team}}{4} - 0.50 \times (\text{Number of tasks you saw})$$

For example, let’s say you saw 12 tasks and solved 10 of them correctly, and you and your teammates correctly answered 16 tasks in total. Then, in addition to your initial $5.00, you will gain $4.00 as your share from your team’s $16.00 (which is accumulated by your team by giving 16 correct answers in total). From this gain, $6.00 will be subtracted because you saw 12 tasks and each costs 50 Cents to you:

$$\text{Earning} = \$5.00 \ + \ \frac{16}{4} \ - \ \$0.50 \ \times \ (12) \ = \ \$3.00$$

The earnings of your teammates will be calculated by a similar formula for them. Let’s do a similar earning calculation for you in another example. Let’s say, you saw 12 tasks, and answered 10 of them correctly. You and your teammates correctly answered 32 tasks in total. Then your earnings will be

$$\text{Earning} = \$5.00 \ + \ \frac{32}{4} \ - \ \$0.50 \ \times \ (12) \ = \ \$7.00$$

Your final screen will show you how many tasks you answered correctly, and your team's total number of correct answers. The computer will also calculate the total amount you made. You will receive this amount in private at the end.

<u>Instructions for the observer:</u>

In this experiment, you are asked to observe your matched performer while he/she is performing his/her tasks. At the beginning, you will be given $5.00. You are expected to watch the performer's computer screen carefully, and your role is to identify whether the performer completes a task correctly. Use the provided blank page as your report sheet. First, write the ID number of the computer which you are watching on your report sheet.

After completion of each task by the performer, if the computer reports that the task is solved correctly, mark **"C"** next to a task number on your report sheet. If the computer reports that the answer of the performer is wrong, then mark **"W"** next to a task number on your report sheet.

At the end we will collect your report sheet and hand them to the experimenter in the other room. You will earn additional money based on how accurately you reported the performance of the performer:

$$\text{Earning} = \$5.00 + \$5.00 * \frac{\text{number of accurately reported tasks}}{\text{number of solved tasks}}$$

Instructions for Part II: *{given after first part is completed}*

In this part of the experiment, you are not in a team, in other words only your own performance will determine your earnings. Again you will be given $5.00 initially.

Your task is the same as the first part of the experiment. You will be asked to calculate the sum of 5 randomly chosen two-digit numbers that will appear on your screen. In order to see a task, you need to click on the "OK" button on your screen. You may use the scratch paper and pen that we provided you. You cannot use calculators. This part of the experiment is 5 minutes long.

Earning of the performer:

The cost of seeing a task is 50 Cents, and you earn 75 Cents for each correctly solved task. Therefore, for each task you solved correctly, you will earn 25 Cents. Hence, your earning from this part of the experiment will be calculated by the following formula:

$$\text{Earning} = \$5.00 + 0.75 \times (\text{Total correct answers you solved}) - 0.50 \times (\text{Number of tasks you saw})$$

Your final payment will be the sum of your earnings in parts I and II.